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Obesity, Income and Gender: The Changing Global Relationship

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Obesity, Income and Gender:

The Changing Global Relationship

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Abstract

Obesity is considered one of the major health concerns of the 21st century and is frequently associated with economic development. This paper reviews evidence on internal (within countries) and external (across countries) relationships between obesity, income and gender. Obesity changes with income, but in a non-linear way. On average, obesity increases with income in poor countries, has no relationship with income in middle-income countries and decreases with income for rich countries. Within countries, obesity is concentrated among richer groups in low-income countries and evenly distributed in middle-income countries. In high-income countries, the poor are the most obese. The relationship differs for men and women. Women are more obese in low-income countries and much more obese in middle-income countries. The gender obesity gap disappears in high-income economies. The geographic concentration of obesity also changes with income growth: from urban areas in poor countries to rural areas in rich countries. Despite these patterns, total obesity rates continue to increase in all countries, and for the world as a whole.

Keywords: Obesity, Income, Gender, Urbanization

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Obesity, Income and Gender: The Changing Global Relationship

1. Introduction

Obesity is considered one of the major health concerns of the 21st century. As obesity is not only associated with higher mortality (Waxman & World, 2004), but also decreases quality of life and heightens the risk of type II diabetes, cardiovascular disease, hypertension, gallbladder disease, and various cancers (James et al., 2004), it is important to recognize global obesity variations in the context of health and food policies and economic development. Worldwide, the amount of people categorized as overweight now surpasses those categorized as underweight (Mendez et al., 2005; Popkin, 2007). Obesity furthermore presents large external costs to society (Curtis & McCluskey, 2004; Parks et al., 2012), accounting for about 2-6% of total health care costs (WHO, 2007). Identifying best practices in the fight against alarming obesity rates remains challenging due to large cross-country differences (Flynn et al., 2006; Dombrowski et al., 2010). The search for effective policies that prevent long-term obesityrelated health problems therefore requires a good understanding of which groups are most vulnerable to obesity.

Obesity is frequently associated with economic development and income growth. For example, it is often emphasized that recent growth in developing countries has led to a rapid increase in obesity (Misra & Khurana, 2008). However, the association between obesity and income is more complex than often argued.

Studies have documented seemingly contradictory observations on the relationship between obesity and income. Several studies show that obesity levels tend to increase when poor countries become richer, suggesting that the relationship between income and obesity is positive (Popkin, 1998; Wells et al., 2012; Malik et al., 2013). However, other studies show that obesity is highest among the least well-off groups in high-income countries, suggesting that the relationship is negative (Giskes et al., 2008; Sallis & Glanz, 2009). In this paper, we will explain

how and why both relationships can occur by documenting patterns and reviewing evidence on internal (within countries) and external (across countries) relationships between obesity and income and how they change with economic growth and development.

We identify important gender differences in the relationship between obesity and income. Various studies have documented that obesity prevalence is higher for women than for men in specific countries (Swinburn et al., 2011; Roemling & Qaim, 2012; Popkin & Reardon, 2018). As we will show, these gender differences are especially important in middle-income countries, and much less so in the poorest and richest countries. Gender distinctions are important as obesity-related illnesses, such as hypertension and diabetes, are especially harmful to female health, and because maternal physiology influences that of their children, prepositioning them to a higher risk of obesity themselves (Ordovas, 2007; Armitage et al., 2008).

Finally, we also analyze rural-urban differences in obesity and how these relate to income. We show that the geographic concentration of obesity also changes with income growth, from urban areas in poor countries to rural areas in rich countries.

2. Across-Country Observations

2.1. Low- and middle-income countries

A large literature documents that obesity increases with economic development, measured by gross domestic product (GDP per capita), for low- and middle-income countries (Ezzati et al., 2005; Lobstein & Leach, 2007; Egger et al., 2012). This relationship is illustrated in Figure 1, which displays the evolution of obesity prevalence with GDP per capita using data from the World Health Organization (2016) and the World Bank (2016).¹ The line in Figure 1 represents the estimated average level of obesity for each level of income. Table 1 summarizes the

 $^{^{1}}$ Economists typically use the logarithm of GDP rather than GDP in illustrations – as has been used on the x-axis of Figure 1.

quantitative results from statistical model estimations of the relationship between obesity and income (and their statistical significance), for the world as a whole and for different categories of income and gender.

[INSERT FIGURE 1 HERE]

Figure 1 and Table 1 document that obesity rates increase with income in poor countries. There are several reasons for this. As the poor grow richer they can afford more food. Moreover, as income increases people not only eat more but their diet portfolio changes, and not necessarily to a healthier basket (Drewnowski & Popkin, 1997). As income rises, diets shift from traditional home-cooked meals to ready-made processed food and a more "westernized" diet. Income growth is also associated with a change in lifestyle and occupation. The poor often work in labor-intensive manual jobs that require high levels of energy expenditure, while higher income economies are associated with a more sedentary lifestyle involving less energy-intensive jobs.

Culture and social preferences may also play a role. Studies show that in developing countries, a larger body mass is sometimes preferred as it is associated with power, beauty, health and affluence (Fernald, 2009). Brewis et al. (1998) found this in the Polynesian Islands. Kruger et al. (2005) furthermore found that in African countries thinness was often associated with HIV/AIDS and other diseases, resulting in positive attitudes towards a larger body size. Rguibi & Belahsen (2006) also found that an image of an overweight person was seen to be healthier than the skinnier options in a study in Morocco.

Another factor is that access to healthcare, education, wholesome food and recreational activities promoting weight management remain relatively scarce in low- and middle-income countries (Malik et al., 2013). Finally, urbanization rates, which are correlated with income growth, may also play a role as a larger percentage of the population is confronted with more

energy-intensive diets, higher in processed foods, sugar and oils, typical of urban regions (Popkin 2006). The combination of these factors makes that obesity rises with income (Popkin et al., 2012).

2.2 Middle- and high-income countries

However, the positive relationship between obesity and income changes at higher levels of income. There is no longer a significant relationship between income and obesity once a certain income level has been reached (Ezzati et al., 2005; Dinsa et al., 2012; Egger et al., 2012). Figure 1 illustrates that for the range of middle-income countries, which includes countries such as Russia, Turkey and Brazil, there is no significant (positive or negative) relationship between income and obesity.

The data and other studies also suggest that as incomes increase even further that the relationship between income and obesity may change from positive to negative, and that average obesity is lower again at the highest income levels (e.g. Groth et al., 2009). Rokholm et al. (2010) find that childhood obesity is decreasing in countries such as Sweden, Switzerland, France and Australia.

The regression results in Table 1 support these conclusions. There is a significant non-linear relationship between income and obesity, reflected in the significant estimates of the quadratic term of the regression (for "all countries" in column (1)). This changing relationship is also consistent with the statistical analyses for the three different income groups (columns (2) to (4) in Table 1). The coefficient of GDP per capita shifts from significantly positive in low-income countries (column (2)) to not significant in middle income countries (column (3)) to negative in high income countries (column (4)). The negative effect in high-income countries is not significant for the population as a whole but it is for women. This suggests significant gender differences, which we will discuss in Section 5.

One can calculate the maximum of the obesity-income relationship using the quadratic regression results and thus identify the "turning point". The declining trend in obesity at higher income levels starts at an income level of about 43,000 US dollar (US\$)², approximately the income level of Finland today.

[INSERT TABLE 1 HERE]

The literature has forwarded some reasons for the changing relationship between income and obesity at higher income levels. One factor is the adverse reaction to obesity and the social stigma of being overweight in high-income countries (Prentice, 2005). As explained above, this is different from cultural and social preferences in low- and middle-income countries, where a larger body mass is desirable. Popkin (2014) argues that the effect of cultural differences for body size preferences are reinforced by the supply, availability, and affordability of specific types of food. For example, food shops and supermarkets in low- and middle-income countries offer mostly processed and ready-made meals, while supermarkets in rich countries increasingly offer a wide variety of fresh fruits and vegetables, low calorie foods, "superfoods", etc. This is not only due to differences in preferences to spend on healthy diets, including fresh fruit and vegetables, high-quality meat and fish. In addition, access to healthcare, education and recreational activities promoting weight management are more available in high-income countries (Malik et al., 2013). So, also here, it is a combination of factors that cause a different relationship between obesity and income than in lower income countries.

² This is calculated from the quadratic equation for total obesity levels in Table 1.

3. Within-Country Observations

Studies also document a changing relationship between income and obesity *within* countries – and these changes are consistent with the changing relationship documented *across* countries. In low-income countries obesity prevalence is found to be highest among the upper-class (Mendez et al., 2004; Jones-Smith et al., 2012). This phenomenon has been highlighted as part of the double burden of malnutrition, with large portions of the population suffering from underconsumption and micronutrient deficiencies, while overweight and obesity are also (and increasingly) a problem (Swinburn et al., 2011). Figure 2 illustrates how in countries such as Benin and Ghana, with a GDP per capita around 1,000US\$ to 1,500 US\$, obesity is more prevalent in higher income groups³. While obesity rates in Benin are still relatively low at every level of income, obesity in Ghana reaches about 45% for the highest income groups. In Benin and Ghana, the poorest 20% of the population only make up about 2-7% of the total number of obese people (Table 2).

[INSERT FIGURE 2 HERE]

Figure 2 and Table 2 also illustrate how the distribution of obesity shifts from being concentrated among richer people in low-income countries to being relatively equally distributed in middle-income countries. In middle-income countries like the Dominican Republic and Turkey, with a GDP per capita between 7,000 US\$ and 11,000 US\$, obesity prevalence is relatively similar at all income levels. In middle-income countries poverty and obesity are similarly distributed. In the Dominican Republic and Turkey about 15-21% of obese people belong to the poorest 20% of the country (see Table 2). Income differences are thus not a major factor influencing obesity levels in these countries.

³ In figure 2, data on female obesity is used as data for total and male obesity rates is not available for most lowand middle-income countries.

[INSERT TABLE 2 HERE]

The shift from obesity being a problem for richer people in low-income economies to (also) being a problem for poorer people continues at higher incomes (Martorell et al., 2000; Monteiro et al, 2004). Griffith et al. (2016) document that in high-income countries, like the UK, obesity is most prevalent among the poorest. Figure 2 illustrates that in high-income countries such as Spain and Germany, with a GDP per capita of 30,000 US\$ and above, obesity prevalence is lowest in high-income groups and highest among the poorest in society. In Spain and Germany, the poorest 20% make up 26-27% of the total number of obese people (Table 2).

In high-income countries the brunt of the obesity burden thus falls on the poorest in society. It is the richer people in high-income countries that are more health aware, can allocate more time and resources to healthy diets and exercise regimes, while the poor consume more fat, sugar and energy-dense food, as diets high in lean meat, fish, vegetables and fruit are too expensive (Drewnowski & Darmon, 2005) or scarcely available (Wrigley, 2002; Walker et al., 2010). Here it appears that both supply and demand factors play a role. On the supply side, recent studies have associated the relatively high price and low availability (and high opportunity costs) of healthy foods for the poor with so-called "food deserts", i.e. the absence of fresh and healthy produce in supermarkets, or the absence of supermarkets altogether, in low socioeconomic areas in countries such as the US (Walker et al., 2010) and the UK (Cummins & Macintyre, 2002).

4. Evolution Over Time

4.1. Obesity and income growth patterns

The non-linear relationship between income and obesity may suggest that if countries and people become richer over time that their obesity rates will stop growing and may eventually decline again. However, if we look at changes in obesity over time, there is the striking observation that obesity levels have never decreased in any country so far. Hence, the observed negative correlations between income and obesity at the higher income levels should not be interpreted as that obesity *levels* will decline when incomes grow, but rather that obesity *growth* with income is slower in rich countries than in middle-income countries.

[INSERT FIGURE 3 HERE]

This conclusion is illustrated in Figure 3, which shows how obesity and incomes have evolved over the 50 year period between 1976 and 2016. Since it was not possible to include all countries, Figure 3 illustrates these historical changes for the six countries included in Figure 2. The first key observation is that obesity has increased everywhere – i.e. in all countries and in all time periods (see Figure 3A). This is not only the case for the six countries in Figure 3, it is the case for all countries in the WHO dataset.

A second observation is that during the latest decade in the data (from 2006 to 2016) the curves become steeper for the richest countries. Although part of this is caused by the log-scale on the horizontal axis, it does suggest that there has been a significant increase in obesity in the middle- and high-income countries despite limited growth. In fact, in the case of Spain, obesity has increased by 5 percentage points (from 22% in 2006 to 27% in 2016) despite a decline in incomes caused by the economic crisis of 2009.

The third key observation is that the obesity growth rates differ significantly between income groups. They are lowest for poor countries and highest for middle-income countries (see Figure 3B). Obesity has grown by about 22 percentage points in the Dominican Republic and by 24 in Turkey, much higher than in the poorest countries (7 in Benin and 8 in Ghana), but also significantly higher than in the richest countries (around 16 for Spain and Germany).

These differential growth rates are not just the case for these six countries. The growth patterns in Figure 3 are consistent with average growth patterns across all countries. Figure 4 illustrates how, over the period 1976-2016, the average growth of obesity prevalence was lowest in low-income countries with 7.4 percentage points. Middle-income countries experience the strongest growth in obesity with 17.0 percentage points. For high-income countries, obesity growth was a bit less, but still high (15.8 percentage points).⁴

[INSERT FIGURE 4 HERE]

The result of this continued growth of average obesity levels over time, and the differential growth rates of obesity between income groups, is that the relationship between obesity and income is also changing over time. Figure 5 illustrates how the estimated relationship of average obesity with income is moving upwards over time, in particular in the middle- and high-income regions. Hence, while the difference between obesity levels is getting smaller at middle and higher income levels (as we documented in Sections 2 and 3), the overall obesity level is simultaneously increasing.

[INSERT FIGURE 5 HERE]

Moreover, the historical changes are large. At an average income of 10,000US\$ per capita – an income level close to that of Turkey and Argentina today (and which corresponds to a level of 4 on the horizontal log GDP per capita axis in Figures 1 and 5) – the average obesity level was 10% in 1976, 16% in 1996 and 23% in 2016. This can also be seen from Figure 3A: the income level of Turkey in 2016 was approximately that of Spain in 1990 and of Germany in

⁴ Studies analyzing within-country differences, following children from a variety of households with differing socioeconomic statuses, yield similar conclusions. Children from poor households are more likely to face issues of overweight or obesity in adulthood (Poulton et al., 2002; Power et al., 2005).

1980. However, the obesity levels for Turkey in 2016 (33%) are much higher than those for Spain in 1990 (17%) and for Germany in 1980 (12%).

The more rapid growth in obesity levels for middle-income countries compared to highincome countries can be, at least partially, attributed to biological factors (Prentice et al., 2005). An extensive literature, commencing with the Barker (1994) hypothesis, states that fetal undernutrition is an important contributor to obesity. Fetal malnutrition triggers a host of hormonal, anatomical and physiological changes that improve child survival in a food insecure environment (Gluckman & Hanson, 2006). However, if paired with a resource-rich postnatal environment, these genetic alterations may contribute to a more accelerated weight gain. These theories are supported by studies analyzing the long-term effect of maternal famine exposure on children born afterwards (Ravelli et al., 1999; Clarkin, 2008). Adults living in middleincome countries, are more likely to have suffered from malnutrition during their fetal development, compared to adults living in high-income countries. The chance that these adults become obese later on in life is therefore greater when experiencing income growth.

A similar biological effect comes from food insecurity in early childhood. Infant stunting leads to an impaired fat metabolism (Hoffman et al., 2000) and a relatively higher gain in fat mass compared to lean body mass (Martins et al., 2004). Until quite recently, middle-income countries still had a high prevalence of stunting, a typical indicator of food insecurity. The average stunting rate in middle-income countries was 43.8% in 1990 (Table 3). These rates have improved significantly over the past two decades (to 23.0% in 2016). However, it implies that many more adults in middle-income countries (who were born before 1990) have experienced stunting, affecting their fat metabolism and stimulating obesity, compared to high-income countries (where stunting was on average less than 5% in 1990).

A related explanation for the differences in obesity levels between middle-income and highincome countries is through psychological channels. After periods of deprivation, an increased excitement over the ability to buy more foods accompanied changing food preferences. Russell et al. (2016) find that children from the most deprived income quintile are more likely to consume "feel good" foods and less likely to consume fruit and vegetables in adulthood. Higher childhood exposures to stress are associated with rapid weight gain during adolescence (Koch et al., 2008). Middle-income country adults are more likely to have experienced periods of hunger or nutritional deprivations, increasing current and future obesity rates as parental eating behaviors influence the development of their children's eating behaviors (Savage et al, 2007).

These biological and psychological factors are reinforced by fast structural changes in food distribution systems in middle-income countries, often referred to as the "supermarket revolution" (Reardon & Berdegue, 2002), rapid urbanization (Smil, 2001) and the decline in food prices (Schmidhuber & Shetty, 2005). In combination with social and cultural differences in high-income countries leading to behavioral changes (discussed above) these factors cause a stronger growth in obesity in middle-income countries than in high-income countries.

4.2. Economic development and global obesity

The country obesity-income relationships and growth patterns discussed so far are based on unweighted country averages. This means that large countries have the same impact on the relationship as small countries. This is an appropriate approach as large and small countries are equally valid as data points in this analysis. However, if we want to obtain an idea about the relationship between obesity and income from a global health perspective, it is also useful to look at the relationship taking into account the number of (obese) people living in each of these countries. From this we can determine how large of an issue rising obesity rates are in absolute numbers of people. In Figure 1, the two most populated countries in the world, India and China, are far below the estimated (average) relationship. This suggests that taking the number of people into account may yield a different relationship or growth pattern.

Figure 6 therefore illustrates the world growth pattern of obesity and income with population-weighted and unweighted country data. The difference is substantial. The average global obesity level in 2016 is 19% with unweighted data and 10.5% with population-weighted data. Much of this is due to the fact that some of the largest countries, especially China and India, have lower levels of obesity than the average for their income category, and thus pull down the average when their size is taken into account⁵. The weighted income levels are substantially higher than the unweighted, moving the curve to the right.

[INSERT FIGURE 6 HERE]

That said, some key conclusions are the same for both patterns. There has been significant growth in obesity over the past 50 years and this is correlated with significant income growth. During the latest decade in the data (from 2006 to 2016) the curves clearly change, becoming almost vertical. Despite relatively limited income growth, there has been a very significant increase in obesity globally (around 3 to 4 percentage points depending on the indicator).

5. Gender Differences

5.1. Across countries

In many countries there are important differences between male and female obesity rates. Globally, the prevalence of obesity is around 50% greater for women than for men (Wells et al., 2012). However, this gender gap is not the same for all countries (Garawi et al., 2014).

⁵ Some studies have cautioned against a common measure of obesity across cultures and regions (Hoang & Wong, 2007; Wen et al., 2009). They argue that South- and East-Asians face greater adverse metabolic effects of a BMI over 30 (the standard global definition of obesity) compared to Caucasians. They suggest to define obesity by a BMI greater than 25 in South- and East-Asian regions. This would bring the two lines in Figure 6 closer together.

Interestingly, these gender differences are also correlated with income. More specifically, the gender obesity gap is much higher for middle-income countries than it is for low-income countries or high-income countries. Panel A of Figure 7 illustrates the estimated relationship between average obesity levels and income for males and females – similar to Figure 1 but now disaggregated by gender. Panel B of Figure 7 presents the gender obesity gap, which represents the difference between the two graphs in Panel A, and how it evolves with income.

[INSERT FIGURE 7 HERE]

The female obesity relationship with GDP per capita follows a clear non-linear trajectory increasing until a certain income level and declining afterwards. The positive relationship in low-income countries and the negative relationship in high-income countries are both statistically significant (see Table 1). There is no significant relationship between income and female obesity for middle-income countries.

For males, the relationship between obesity and income is somewhat different. Obesity increases for all income levels, and although the curve levels off, there is no turning point in the regions (countries) included in the WHO database.

For most countries, female obesity is higher than male obesity. In the poorest countries, average obesity is already higher for women. At higher levels of income, the gender obesity gap widens further, with the average number of obese women growing more rapidly than men. The gender obesity gap peaks for middle-income countries. Note that there is still large variation in the observations. For example, in several middle-income countries in Eastern Europe (such as Bulgaria, Hungary, Romania and Slovakia) and in some African countries (such as Nigeria), men are more obese than women. At the peak, the gender obesity gap is almost 10 percentage points (see Figure 7B), with the average obesity prevalence for women

around 24% and for men close to 15% (see Figure 7A). In other words, on average, women are 60% more likely to be obese than men at these income levels.

Beyond this peak, the gap closes as female obesity first slows down and then starts declining, while that of men keeps rising, albeit slower. For women, the change from a positive to a negative relationship between obesity and income is at an income level of about 38,000⁶ US\$, significantly below the estimated turning point for the total population (around 43,000 US\$). For male obesity, there is no turning point in the estimated global relationship presented in Figure 7, only a slowing down of the increasing obesity rates.

The result of these diverging trends is that at high-income levels there is no longer a significant gender difference in average obesity prevalence. The trend line suggests that the obesity gap may even reverse at high levels of income, with males becoming the more obese gender. This is already the case in Japan, in all Scandinavian countries, and in Northern European countries like Belgium, France, Switzerland and Germany.

5.2. Over time

The conclusion from the cross-country data analysis is consistent with the analysis of historical data and how obesity has grown for men and women over the 50 year period between 1976 and 2016, as illustrated in Figure 8. Panel A of Figure 8 illustrates these historical changes for three of the six countries included in Figure 2 and 3. Panel B illustrates the historical evolution for several large countries.

[INSERT FIGURE 8 HERE]

The key findings are consistent across the graphs. In low-income countries, such as Benin (Panel A) and India (Panel B), male and female obesity rates start off at similar levels in 1976,

⁶ Calculated from the quadratic regression of female obesity in Table 1.

but over time, the obesity rates start to diverge, with female obesity growing faster. In middleincome countries, such as Turkey (Panel A) and Russia (Panel B), there is a large gap with female obesity rates roughly twice as high as those for males. In high-income countries, such as Germany (Panel A), and France and the USA (Panel B), male and female obesity rates converge again. In 1976, women had higher rates of obesity in all three countries but by 2016, male and female obesity prevalence is almost the same, with males already having higher obesity rates in Germany.

An important point to emphasize is that the "gender convergence" in obesity at high income levels is not due to the fact that female levels of obesity are actually declining, but because obesity among women is growing slower than for men. Figure 8 shows, just as Figure 3, that obesity levels have not decreased so far, neither for men nor for women. Hence, the convergence of gender obesity levels at higher income levels is not because female obesity *levels* have declined when incomes grow, but rather that obesity *growth* with income is slower for women than for men at high income levels.

The illustrated patterns in Figure 8 are consistent with the average changes for all countries. Figure 9 displays the average growth rates for obesity in low-, middle- and high-income countries between 1976 and 2016 for men and women. In low-income countries, obesity growth is stronger for women (9.8 percentage points) than for men (4.8). In middle-income countries, female obesity still grew more (18.3) than male obesity (15.5). However, in high-income countries the growth in obesity prevalence for women declined to 14.4, while it continued to increase for men (17.7 percentage points).

[INSERT FIGURE 9 HERE]

5.3. Within-country observations

The data suggest that for males the obesity-income relationship may also eventually turn around at (very) high income levels. Firstly, our statistical analyses show that while there is a strong positive relationship between average male obesity and country incomes at low levels of income, this is no longer significant for middle-income countries, and even less at high levels of income (Table 1).

Secondly, although within-country obesity distribution data for men are only available in high-income countries, the available data do suggest that there is also a negative relationship between obesity and income in high-income countries for men, as there is for women. Available data are presented in Figure 10 for Germany and Spain. The illustrated relationship is negative, but less strong than that for women (see Figure 2) – consistent with the across-country differences.

[INSERT FIGURE 10 HERE]

5.4. Explanations for the gender obesity gap

There are several explanations for these (changes in) gender differences in obesity and income. Studies show that, at the lowest levels of GDP, females often have less access to nutritious food because they are less income secure and have lower wages than men (Wells et al., 2012). Garawi et al. (2014) furthermore argue that discriminatory social practices that are rooted in the economic, political and social structures of developing societies may lead to higher female obesity. Improving women's status may therefore be key in addressing the global obesity epidemic in the long-run, not only benefitting women themselves but also their offspring (Wells et al., 2012).

Cultural aspects may also play a role. As explained in Section 2, studies conclude that in various low- and middle-income countries a larger body size is preferred, as it is seen as a desired status signal and a sign of health and prosperity (Holdsworth, 2004; Fernald, 2009). This seems to be particularly the case for women as it is also seen as a sign of higher fertility (Kanter & Caballero, 2012).

The growth of the gender obesity gap in middle-income countries seems to be caused by several factors. On the one hand, middle-income countries continue to experience similar issues of female inequality and status as low-income countries. The transition away from agrarian jobs has also decreased the physical activity of women more than for men (Ismail et al., 2002; Snodgrass et al., 2006). In addition, women now also face a growing opportunity cost of time. Here the growing market for time-saving, pre-packaged foods have contributed further to already alarming obesity levels (Popkin, 2006), especially in urban centres (more on this in Section 6). This may have especially large effects on women as they are over-motivated to ensure food security in later life after having experienced periods of deprivation during childhood (Olson et al., 2007). Hence, the combination of these factors is likely causing a growing gap in obesity levels between men and women in middle-income countries.

In rich countries, several studies document gender differences in healthy behavior and diets with women being more likely to focus on healthy eating and activities (Zunft et al., 1997; Furnham & Kirkcaldy, 1997; Fagerli & Wandel, 1999; Wardle et al., 2004). Although women have a higher preference for dairy-based comfort foods (Wansink et al., 2003), men in both the United States and Europe show a higher intake of other food and drinks contributing to obesity, such as alcoholic beverages (Kant et al., 2007; Castetbon et al., 2009). Cultural factors and social network effects may reinforce this (Courtenay, 2000; Christakis & Fowler, 2007).

Analyzing these gender differences and their causes is important not only for people themselves but also for future generations. As female obesity predispositions future generational weight issues of both males and females through metabolic imprinting, it is imperative to carefully analyze these gender disparities (Sullivan & Grove, 2010; Josefson, 2012).

6. The role of urbanization

Economic development and income growth are correlated with urbanization.⁷ Many studies have argued that urbanization is a key factor in the global rising obesity rates (Christensen et al., 2008; Wagner & Brath, 2012, Malik et al., 2013). However, also here the relationship is more complex than often argued.

Initially, urbanization was mostly seen as a positive influence on food security as it was associated with declining undernourishment (Delgado, 2003; Huang & Bouis, 2004). However, from 2000 onwards, studies pointed at urbanization and overconsumption. They argued that urban areas in lower income countries shifted towards more energy intensive diets, dominated by processed 'fast-food' and higher oil and sugar intakes, with a growing dependence on street foods (Popkin, 2006). In some countries, street foods account for almost three-quarters of the total calorie intake of the urban poor and middle-income groups (Maxwell et al., 2000; Kinabo, 2004; Maruapula et al., 2011). Urban diets are therefore lower in essential vitamins, minerals and fibre, and higher in energy, fats and sugars (Kearney, 2010; Ameye, 2017). Combined with a more sedentary lifestyle, this leads to increases in obesity (Popkin et al., 2012).

Interestingly, recent studies provide apparently contradictory evidence showing that it is in fact rural areas driving up global obesity rates (Jaacks et al., 2014). Bixby et al. (2019) find that

⁷ The correlation between GDP per capita and the percentage of urban population is 60% (WB, 2016).

over 55% of the rise in global BMIs between 1985 and 2017 come from rural areas, with this percentage reaching more than 80% for low- and middle-income countries. These figures indicate a closing and even reversal in the gap between rural and urban obesity rates, which Popkin & Reardon (2018) suggest may be due to the transformation of rural areas to resemble urban areas.

In the rest of this section we analyse the relationship between obesity and urbanization, identifying patterns with our data as in previous sections.

[INSERT FIGURE 11 HERE]

Figure 11 compares obesity rates from rural and urban regions using the most recent DHS and European Health Interview Survey data. Pooling all countries, urban obesity rates are on average 3% higher than those in rural regions, at about 20% and 17% respectively. However, when dividing our sample into low-, middle- and high-income countries, we find that differences in obesity rates between rural and urban regions change.

In low-income countries, urban areas have much higher levels of obesity: 18% compared to 7% in rural areas. In middle-income countries the difference between rural and urban obesity is smaller, with high obesity rates in both areas, at 29% and 26% respectively. In high-income countries, the pattern reverses. Rural regions have higher levels of obesity at 19% compared to 15% in urban areas.

[INSERT FIGURE 12 HERE]

Figure 12 presents the change in obesity prevalence for rural and urban regions. Data are only available for low- and middle-income countries from 2001 to 2012⁸. For low-income countries, rural obesity levels are lower than urban obesity levels, in all time periods. In middle-

⁸ These are rough dates depending on year of data collection.

income countries, there is a clear convergence in obesity rates. Urban obesity rates were higher from 2001 to 2006, but rural obesity rates caught up from 2006 to 2012. Hence, while there are no historical data on changes over time for high-income countries, what is available shows patterns of convergence between urban and rural areas in middle-income countries.

[INSERT FIGURE 13 HERE]

These rural-urban obesity patterns are also mirrored in the distribution of obesity by income groups within countries. To compare with Figure 2, we separate the rural and urban population in low- and middle-income countries⁹ in Figure 13. In the low-income countries (Benin and Ghana) total urban obesity is much higher than rural obesity. However, the increasing relationship between household income and obesity holds in both rural and urban areas in Benin and Ghana. Moreover, the obesity gap between the income categories is much larger than the urban-rural differences within income groups.

The relationship is different in middle-income countries. The total gap is smaller. In Armenia, rural obesity is already higher than urban obesity. Rural obesity rates exceed those of urban areas, at all income levels. In the Dominican Republic, urban obesity is higher overall, but especially in income category 2 and 3. At higher income levels, rural areas have obesity levels equal to or higher than urban areas.

In summary, available data indicate that obesity is higher in urban areas in poor countries, but lower in urban areas in rich countries. Despite incomes being typically higher in cities, they are often associated with unhealthier food options and limited space for physical exercise in low- and middle-income countries (Pirgon & Aslan, 2015). Hunger and macronutrient deficiencies are less common in megacities, but these go paired with large micronutrient

⁹ Data on both within-country wealth categories and rural-urban classifications are not available for high-income countries. Turkey is replaced by Armenia, a middle-income country for which we have data.

deficiencies, indicating a lower quality diet. Households living in urban slums also have limited cooking facilities to provide wholesome meals, therefore relying on unhealthy street food and fast-food for sustenance. These phenomenon reverse in high-income countries, where urban areas are associated with increased availability of organic and health foods, as well as exercise and sports facilities. This transition from urban to rural areas as main location of obesity occurs when countries reach "middle-income" status.

7. Summary and Conclusions

Obesity changes with income, but in a non-linear way. This relationship also differs for men and women. These conclusions follow from a range of studies and data analyzing both crosscountry and within-country differences in obesity prevalence. The complex relationship between obesity, income, urbanization and gender is summarized in Table 4.

Globally, obesity is lowest in the poorest countries and is higher for countries with a higher GDP per capita. At middle-income levels there is no significant correlation between incomes and obesity levels. For high-income economies, the correlation is negative, but only significant for female obesity.

This non-linear relationship is not because obesity actually declines with income growth in higher income countries. In fact, average obesity levels have never decreased in any country thus far. The observed negative correlations between income and obesity at the higher income levels is because obesity *growth* with income is slower in rich countries than in middle-income countries.

The change of average obesity with income is also reflected in changes of the obesity distribution within countries. In poor countries, it is the richest part of the population that is

more obese. In middle-income countries there is little correlation between income and obesity. In rich countries, obesity is concentrated among the poorest groups of the population.

There are significant gender disparities in obesity prevalence worldwide. Females are more obese in low-income and middle-income countries, with the gender gap being highest in middle-income countries. For middle-income countries, this gap also widens over time. In highincome economies, the gender obesity gap disappears as the growth of female obesity is slower than that of male obesity.

Urbanization, which is correlated with income, is also correlated with obesity in a non-linear way. In low-income countries obesity is higher in urban areas than in rural areas. In high-income countries the rural-urban obesity gap is reversed.

A series of studies have tried to identify the causes of these differences and the changing relationship with income. They show that a combination of several factors, including economic, social, cultural, institutional, psychological and biological factors, play a role. Addressing obesity problems therefore requires an approach that targets more than just one factor or cause. Still, there is much to learn. An important area for future research is to better understand which factors explain these differences, to what extent these effects are conditional to specific circumstances and how these insights can be used to design better prevention campaigns and more effective targeting of health policies in this area.

A possible positive insight from our analysis, for the design of policies and campaigns to address obesity across the globe, is the variation in obesity levels among low- and middleincome countries. This variation is very large, meaning that although the average patterns are clear, there are potentially important lessons that can be drawn from countries with similar income levels but relatively low levels of obesity (or gender gaps) in order to reduce the obesity rates in the countries, or groups within the country, with a high obesity prevalence.

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[dataset] Demographic and Health Surveys, Benin (2011), Ghana (2014), Dominican Republic (2013)

[dataset] European Health Interview Surveys, Turkey (2014), Spain (2014), Germany (2014)
[dataset] World Health Organization (2016). Prevalence of obesity among adults, BMI ≥ 30.
Global Health Observatory

[dataset] World Bank (2016). GDP per capita (Current US\$)



Figure 1 | Worldwide obesity prevalence and GDP per capita

Source: Authors' calculations with data from the WHO (2016) and WB (2016)



Figure 2 | Within-country female obesity prevalence and income*

Source: Demographic and Health Surveys (Benin 2011, Ghana 2014, Dominican Republic 2013), European Health Interview Surveys 2014 (Turkey, Spain, Germany)

* For low- and middle-income countries, this type of data is only available for females.





3A: Obesity and income 1976-2016

3B: Growth in obesity prevalence (% points) between 1976 and 2016



Source: Authors' calculations from the WHO (1976, 1986, 1996, 2006, 2016) and WB (1976, 1986, 1996, 2006, 2016)



Figure 4 | Growth in obesity prevalence (% points) between 1976 and 2016

Source: Authors' calculations from the WHO (1976, 1986, 1996, 2006, 2016) and WB (1976, 1986, 1996, 2006, 2016)

Note: Low-income, middle-income and high-income countries are classified by dividing the range of the log GDP per capita by 3. Low-income countries have a log GDP per capita lower than 3.3 (GDP per capita around 2,000 US\$), middle-income countries between 3.3 and 4.2 (GDP per capita around 16,000 US\$) and high-income countries above 4.2.



Figure 5 | Estimated relationship between countries' obesity prevalence and GDP per capita at different times

Source: Authors' calculations with data from the WHO (1976, 1986, 1996, 2006, 2016) and WB (1976, 1986, 1996, 2006, 2016)



Figure 6 | Evolution of the average global obesity rate and per capita income (simple average and population-weighted average) 1976-2016

Source: Authors' calculations with data from the WHO (1976, 1986, 1996, 2006, 2016) and WB (1976, 1986, 1996, 2006, 2016)



Figure 7 | Gender differences in obesity and its relationship with GDP per capita

7A: Average male and female obesity prevalence and GDP per capita

7B: Difference in average female and male obesity prevalence



Source: Authors' calculations based on WHO (2016) and WB (2016) data

Figure 8 | Evolution of the gender obesity gap from 1976 to 2016



8A: Average female and male obesity prevalence in some low-, middle- and high-income countries (same as Figure 3)

Note: Ghana, Dominican Republic and Spain are omitted to enhance clarity of figure. Ghana follows a similar trend as Benin, the Dominican Republic a similar trend as Turkey, and Spain a similar trend as Germany



8B: Average female and male obesity prevalence in some large countries

Note: China follows a similar pattern as India but with higher income growth over time Source: Authors' calculations based on WHO (1976, 1986, 1996, 2006, 2016) and WB (1976, 1986, 1996, 2006, 2016) data



Figure 9 | Growth in male and female obesity prevalence (% points) between 1976 and 2016 by country income group

Source: Authors' calculations from the WHO (1976, 1986, 1996, 2006, 2016) and WB (1976, 1986, 1996, 2006, 2016)

Note: Low-income, middle-income and high-income countries are classified by dividing the range of the log GDP per capita by 3. Low-income countries have a log GDP per capita lower than 3.3 (GDP per capita around 2,000 US\$), middle-income countries between 3.3 and 4.2 (GDP per capita around 16,000 US\$) and high-income countries above 4.2.



Figure 10 | Within-country male obesity prevalence and income

Source: European Health Interview Surveys 2014



Figure 11 | Obesity prevalence (%) in rural and urban areas in 2014

Source: Demographic and Health Surveys 2012-2014 (Low- and middle-income countries). European Health Interview Surveys 2014 (High-income countries)



Figure 12 | Change in female obesity prevalence (%) in rural and urban areas, 2001-2012*

Source: Demographic and Health Surveys (Low- and middle-income countries). * These data are only available for females in low- and middle-income countries.



Figure 13 | Within-country distribution of female obesity prevalence by income group for rural and urban areas*

Source: Demographic and Health Surveys (Benin 2011, Ghana 2014, Dominican Republic 2013, Armenia 2015). * These data are only available for females in low- and middle-income countries. Data for Turkey were not available to compare with Figure 2 – Armenia also falls in the middle-income category.

		(1)	(2)	(3)	(4)
	Variables	All countries	Low- income countries	Middle- income countries	High-income countries
A. Total Obesity ^b	GDP per capita	0.0274***	0.239**	0.0271	-0.00245
	GDP per capita squared	-3.19e- 05***	(0.103)	(0.0474)	(0.00251)
		(1.08e-05)			
B. Male Obesity	GDP per capita	0.0311***	0.185**	0.0258	0.00204
		(0.00721)	(0.0885)	(0.0467)	(0.00239)
GD cap	GDP per	-3.08e- 05***			
	capita squared	(9.55e-06)			
C. Female Obesity	GDP per capita	0.0265***	0.332***	0.0133	-0.00601**
G	GDP per capita squared	-3.53e- 05***		× ,	
		(1.26e-05)			
	Regional Fixed Effects ^c	Yes	Yes	Yes	Yes
	Observations	178	59	59	60

Table 1 | Relationship between GDP per capita^a and obesity prevalence: regression results

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

^a GDP per capita has been divided by 100

^b The dependent variable is total obesity among adults (A), male obesity among adults (B) and female obesity among adults (C). Data are from the World Health Organization (2016) and the World Bank (2016)

^c Regional effects for Asia, Africa, North America, Central America, South America, Oceania, the Middle East, Pacific Islands and Europe as a reference category.

Table 2 | Share of the 20% poorest in total obesity prevalence

Country	Share of 20% poorest in obesity (%)
Ghana	2.8
Benin	6.5
Dominican Republic	15.9
Turkey	21.4
Germany	25.9
Spain	26.9

Source: Author's calculations based on WHO (2016) data

Income category	1990	2000	2010	2016
Low income	54.1	47.0	39.9	35.9
Middle income	43.8	35.4	27.3	23.0
High income	4.1	3.4	2.8	2.5

Table 3 | Prevalence of stunting over time by country income category (% children under 5)

Source: World Bank Database

Table 4 | Summary

	Cross- country obesity distribution	Within- country obesity distribution	Gender obesity gap	Obesity over time	Urbanization and obesity
Low- income countries	Increasing with income	Highest among richer groups	Female obesity higher than men	Slow growth	Highest in urban areas
Middle- income countries	Constant with income	Evenly distributed	Female obesity much higher than men	Strong growth	Evenly distributed
High- income countries	Decreasing with income	Highest among poorest groups	Female obesity same as men	Medium growth	Highest in rural areas